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On the Reproduction of *Opsanus beta* Goode & Bean.

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(Plates I and II).

Introduction.

The species of toadfish, *Opsanus beta* Goode & Bean, formerly synonymized with *Opsanus tau* (Linnaeus) by most authors but reestablished by Schultz & Reid (1937), has not been studied from a standpoint of its reproductive habits. This form of *Opsanus* abounds in the vicinity of the field station of the New York Aquarium located on Palmetto Key in Charlotte Harbor on the west coast of Florida. In making the studies on the reproductive habits of *Paraclinus marmoratus* (Steindachner), Breder (1939 and 1941), it was encountered on its nests in considerable numbers, especially in Pelican Bay where most of the *Paraclinus* work was carried on. The observations and studies discussed herein were made during 1939, January 25 to February 21, and May 17 to May 31; 1940, June 17 to July 8; and 1941, March 4 to April 1, incidental to other more pressing problems. In 1940 Dr. Louis A. Krumholz acted as assistant at the laboratory, while at the other visits Mr. Marshall B. Bishop acted in that capacity. To both these gentlemen my thanks are due as they made it possible for much more to be accomplished than could have been undertaken without their help.

The Spawning Season.

Nests of eggs of this species may be found only during the early part of the year. The earliest and latest dates on which nests were found, together with the respective water temperatures, are given below.

Dates	Water Temperature
March 9, 1941	67° F.
March 19, 1941	62° F.

During the period of these studies the mean midday water temperature was 67° F. with extremes of 72° and 59°.

Mr. Bishop reported seeing nests in February, 1939, so it may be inferred that the spawning season roughly covers the months of February and March. At times later than the latter month no nests were found and fish that were examined all showed a spent condition, while fishes taken in January and February were ripe.

Location of Nests.

The nests were found located in a variety of cavities. The bottom of Pelican Bay presents a choice selection of cavities of many sorts, for most part of natural origin. Nests studied in 1941 showed the following selections of locations:

Old conch shells	2 nests
Yellow sponge cavities	2 nests
Large tin can (lard container)	2 nests
Large clam shell (*Venus*)	1 nest

Tin cans and similar human trash is very rare in this region, but it will be noted that nevertheless two fishes selected such sites. Incidentally it was a single can, one nest inside and one outside. The other three types of items are apparently the most common objects presenting suitable cavities in the area and doubtless represent the primordial nesting cavities of this species. *Opsanus tau* in the vicinity of New York City nests almostly exclusively in cavities presented by human artifacts but here such places are common while large shells and other suitable natural cavities are comparatively rare.

Size of Eggs.

The large eggs are almost indistinguishable in general appearance from those of *Opsanus tau*, as might be expected. Twelve such eggs carefully measured showed the following diameters and numbers:

Diameter in mm.	Number of eggs
3.9	3
4.0	2
4.1	5
4.2	0
4.3	1
4.4	1
Mean Diameter	4.1
Maximum	4.4
Minimum	3.9

As there frequently is distortion of the eggs due to the pressure of adjacent ones, care was exercised in making the above measurements to include only eggs which could be seen to be perfectly spherical except for their point of attachment. According to Gudger (1910) the eggs

of *Opsanus tau* average 5 mm. in diameter, making them nearly a full millimeter larger than those of *Opsanus beta*.

Parental Behavior.

While *Opsanus tau* is reported by Gudger (1910) to show some parental instinct in both sexes, only males have been noted with eggs in *Opsanus beta*. But then, the present author has seen only males with eggs in the former species. In order to obtain better understanding than could be had in the field on the attitude of these fishes toward their eggs, some were established in laboratory aquaria. Details of two of the most interesting are given below.

A nest in a large conch shell, *Busycon perversum* (Linnaeus), was obtained on March 9 and maintained in an aquarium until March 22 in standing but frequently changed water. The attendant male measured 130 mm. in standard length and represents a fair average size for the species in this region. As set up in the aquarium it is shown in a typical pose in Plate I, Figure 1. Usually the tail of the fish was thrust into the spiral whorl of the shell and when frightened it could back further into it until nearly out of sight, but when disturbed it was more apt to attack than to retire. While in the posture shown the right pectoral fin would be fanned back and forth over the eggs with greater or less vigor. When the fin was agitated rapidly even large particles of foreign matter would be moved from the eggs.

At intervals of a half hour or so the fish would usually shift its position to the other side of the opening and use the left pectoral for a while, as shown in Plate I, Figure 2. This position was not used nearly as much as the former. Incidentally the diagnostic pattern on the pectorals of this species may be clearly seen in these two photographs. The eggs formed a uniform single layer in the shell cavity and, as may be seen in the first photograph, reached far back into the shell. The spawning activity would seem to have taken place with considerable flurry for as may be seen, especially in the second photograph, two eggs are attached to the "roof" of the cavity. The shell is not in the position in which it was originally found, having formerly rested on the upper forward part. This may be noted by the lack of living growth of invertebrates and whitish color of the part on which it originally rested. In this position there could have been only a small crack between the lip of the shell and the sea floor. Presumably the nesting fish had excavated a passage for itself between the shell and the sand. Thus, the incubating fish, on transfer to the aquarium, was forced to adjust itself to the new position in which it found the eggs. Originally it must have done its incubating in a nearly inverted position. Actually most, but not all, of the nests of this species and of *Opsanus tau* seen by the writer have the eggs on the under surface of some protecting object. Consequently the two stray eggs must have fallen to their present position rather than have been knocked upwards. Spawning in an inverted position with such large, heavy eggs, it is rather strange that more do not fall to the bottom, and it may be that the violence of the parents' activity serve to keep them knocked about and upwards until they adhere to a solid surface.

The activity in this nest was greatest at night and the relatively great amount of light in the aquarium seemed to discourage incubating. Darkening the aquarium would usually induce a resumption of activity. On the second day the fish had excavated a place for itself under the shell in which it spent most of the time, coming out at intervals to fan the eggs. At times it would fan a pectoral in its retreat cavity similar to that activity over the eggs. It is not clear whether this was due to a confusion and the activity was merely instinctive to a brooding fish or whether they may sometimes normally circulate water about themselves for other than brooding reasons. At least, other non-brooding specimens have not been noted to behave in this manner. All food was refused by the fish during this period of observation, although a variety of living fishes and small crabs were present in the aquarium. Due to a cold snap in which the temperature in the laboratory aquaria dropped to 69° F, all the eggs of this and other species died. The fish continued as before to incubate them spasmodically and only when they had turned black and began to foul the water from decomposition was the matter terminated.

The eggs of two nests found on a large tin can were taken without the attendant parents and carried on in the laboratory without parental attention. The parts of the can to which they were attached were cut out. The only attention these eggs received was an occasional shaking to remove the settling sediment as noticed. They seemed to be developing as well as those with a parent and, like those, were lost due to low temperature.

Another nest with an attendant parent was found in the cavity under a living sponge, *Verongia fistularis* (Pallas), on March 19, 1941. The parent here was much smaller, 95 mm. in standard length. The eggs were on the roof of the cavity and when transferred to an aquarium the sponge was only tipped slightly so that the fish might be seen in as near its normal position as possible. Plate II, Figure 3, shows this with the fish in its inverted position. The activity of the fish was about like that of the former, but the nest could not be retained as long because of the death of the sponge and subsequent fouling of the aquarium. This nest in an inverted position is shown in Plate II, Figure 4. The eggs, new and still clear and nearly the color of the yellow sponge, may be seen clinging to the irregular cavity mostly as highlights reflect from their upper surfaces. This was a very small clutch of eggs, as were many of those found. None were taken with evidences of more than one laying nor were the quantities such as to demand the products of more than one female. Gudger (1910) found both too many eggs for one female and

eggs in several stages of development in his study of *Opsanus tau* on the North Carolina coast.

Discussion.

It is evident from the preceding data and the work of others on the more northern species that there is at least as much similarity between the spawning activities of these two fishes as there is between their physical attributes. The differences noted would seem to be incidental and due to environmental circumstances rather than specific attributes. For example, the finding of an apparently monogamous habit as compared with a polygamous one would seem to be referable to conditions of the bottom, number of available nesting sites and the consequent chances of success on the part of the males in their efforts. In this region suitable nesting cavities are ubiquitous and there is presumably less competition, crowding and resulting fighting for them than in localities where the competition is keen and a larger percentage of fish are doomed to be unsuccessful bachelors.

The smaller egg size seems to be a real and significant difference but the other details are in substantial agreement, even to the temperature of the water at which reproduction takes place. One noteworthy element in this connection is that in the northern form reproduction takes place when the water reaches its approximate maximum temperature whereas in the southern form reproduction takes place when it reaches its approximate minimum. The eggs incidentally are incubated close to their lower threshold of temperature, although the adults survive much lower temperatures. While the temperatures given by Parr (1935) for the Atlantic coast are not directly referable to the distinctly heteroeurythermal conditions under which *Opsanus* lives, his temperature trends of surface waters bear out this as a general condition. Bigelow & Welsh (1925) give June and early July as the spawning season in Massachusetts, during which time the surface temperature is between 60° and 70° F.

Nichols & Breder (1926) record 67° as a spawning temperature and give June and July as the spawning months in the vicinity of New York City. Hildebrand & Schroeder (1928) found females in a ripe condition from April to October in Chesapeake Bay. Those taken in the later months would almost surely be expected to carry over to the next spring. In connection with dates north and south of this region, June, July and perhaps August would seem to be the months in which actually to expect nesting to take place in this region. Gudger (1910) found nests during these three months at Beaufort, North Carolina, during which time the temperatures reached as high as 81°. It thus appears that these fish spawn for the most part in water in the middle and high sixties extending, where the temperature rise is rapid, into the seventies or even the low eighties.

Goode (1884) quotes Silas Stearns as giving April and May as the spawning time in the Gulf of Mexico. These observations presumably were made at Pensacola. It is not clear whether what we here understand as *O. beta* is referred to or whether the fish were *O. pardus* Goode & Bean. In either case the cooler water about Pensacola as compared to the shallow and easily warmed Charlotte Harbor might well account for the difference in time.

Small specimens are not especially abundant in the winter but one measuring 33 mm. in standard length was taken on March 20, 1941. It would seem to be a stunted specimen from the year previous rather than a precocious individual of the current season. Specimens down to about 60 mm. are not uncommon and seem to be referable to the previous spawning period. Above approximately 90 mm. they are all sexually mature. Since the spawning season is evidently quite short it is inferred that this spread in sizes and lack of distinct year classes is referable to the large variety of environments and fluctuating temperatures in which they are found. Both very local vagaries in temperature and available food could make for large differences in the growth rates.

Summary.

1. *Opsanus beta* spawns on the Florida west coast in February and March in a water temperature of about 67° F.

2. Nesting sites are similar to those of *Opsanus tau*, as are the chief features of its reproductive habits.

3. The eggs average 4.1 – mm. in diameter and are found in clutches, guarded by a male, which are apparently the product of a single female.

4. Both species spawn under about the same temperature although in the north this is approximately the highest temperature reached and in the south the lowest, making the two species respectively summer and winter spawners.

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EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. Brooding male aerating its eggs with one pectoral. This was the most generally used position of this specimen.
Fig. 2. Alternate position of the above fish employing the other pectoral. This position was much less frequent.

Plate II.

Fig. 3. Brooding male with its eggs in a sponge cavity, showing the inverted position.
Fig. 4. Detail of above nest, showing eggs attached to under surface of sponge.